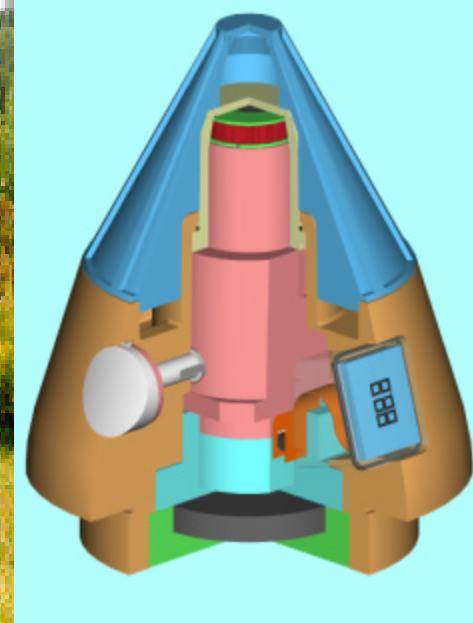
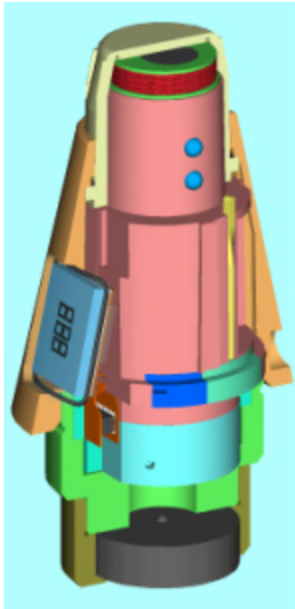


Electronic Time Fuze for Mortars (ETFM)



XM784/XM785
2nd Environment Sensor
30 April 2002

Presented By:
Alliant Techsystems, Inc.
Jim Lucas – Lead Engineer
Phone No. 763-744-5197
Scott Crist – Senior Staff Engineer
Phone No. 763-744-5187



Smooth Bore/Twist Bore Fuzing



- First environment
 - Setback is a robust first environment for both artillery and mortar rounds.
 - Mortar rounds have lower setback magnitudes than artillery rounds but are sufficient to distinguish from non-launch induced environments.
- Second environments
 - Artillery rounds historically employ spin which is a robust second environment sufficient to distinguish from non-launch induced environments.
 - Spin cannot be used for smooth bore mortars
- Second environments have historically separated mortar/artillery fuzing
 - Artillery utilizes mechanically sensed spin and reserve power sources
 - Mortars often utilize air driven turbines to sense air flow and generate power
 - Turbines must be in the air stream resulting in range reduction/environmental concerns

ETFM employs electrically sensed muzzle exit
for a second environment allowing a sealed fuze



2ND Environment Sensor Design Selection

Relative ranking depicted: (-) = least, (0) = nominal, (+) = best

Sensor Candidate	Unit Product Cost	Environmental Reliability	Hardware Complexity	Interference Susceptibility	Technical Risk
Pressure	—	0	—	0	0
Electrostatic	+	0	0	0	0
Magnetic *	+	+	+	0	0
Infra-Red	0	—	0	0	—
RF	0	+	—	0	0
Bore Rider	0	—	—	+	—

Magnetic sensor selected for best overall attributes



ETFM 2ND Environment Sensor Overview

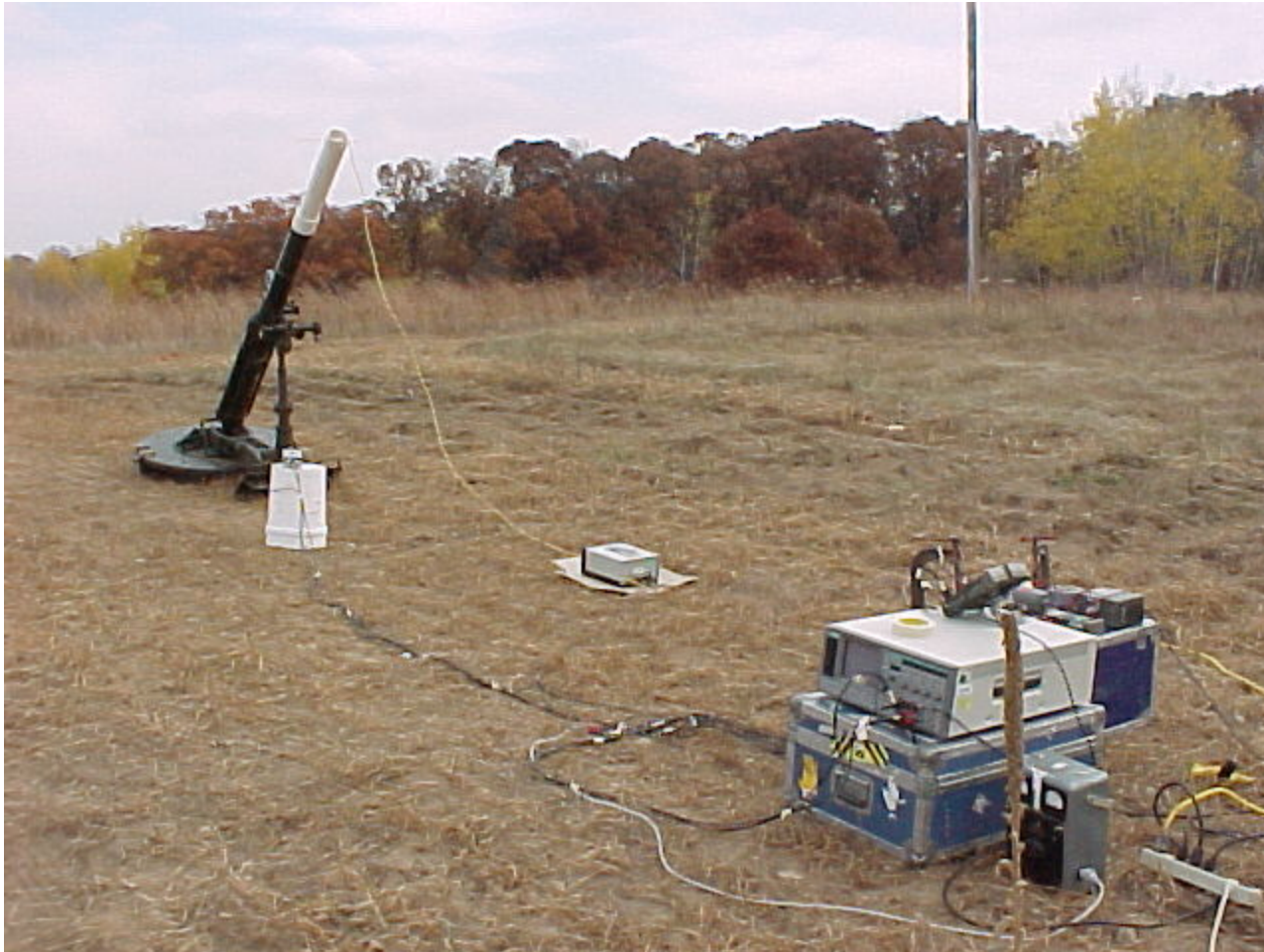
- Traditional Mortar Fuzes:
 - “Air breathing” (turbine)
 - **Exposed / susceptible to environmental conditions**
 - **Reduces maximum range**
 - “Pull wire” (lanyard)
 - **Do not meet Mil-Std-1316**
- ETFM 2nd Environment Sensor senses tube magnetic signatures
 - Passive sensor
 - Detects tube magnetic permanent moment changes and tube exit event
 - Sensor output is rate (velocity) sensitive
 - Single sensor assembly used for Inductive Setting and Tube Sensing
 - Used in spinning and non-spinning (smooth bore) rounds
 - Sensor is a sealed assembly and is not susceptible to environmental exposure or create increased drag



Sensor Development Activities

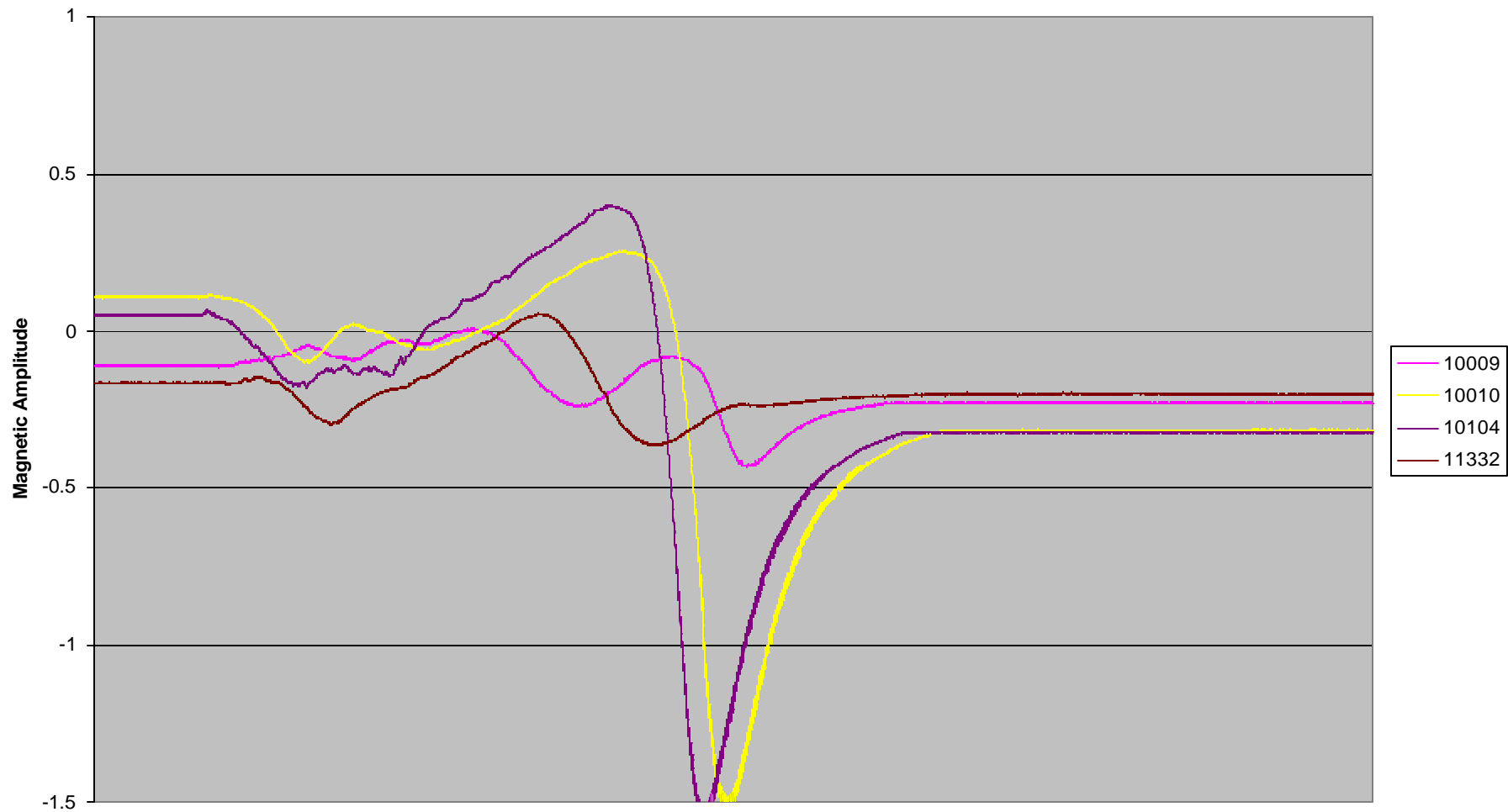
- Collected tube static measurement data on a sampling of 60mm, 81mm, and 120mm mortar tubes at Aberdeen Proving Grounds. Sampling included new tubes and used tubes at various tube elevations and compass directions.
 - Static data is input to a sensor circuit simulation model for design analysis
- Collected tube dynamic (ballistic) measurement data on a sampling of 60mm, 81mm, and 120mm mortar tubes at APG at all charge conditions (ambient temp). Data collected using on-board-recorders included:
 - Magnetic sensor output
 - Setback sensor output
 - Accelerometer (4 rounds)
- Dynamic data is input to the sensor model for design analysis and algorithm development

Sensor Mortar Static Tube Characterization



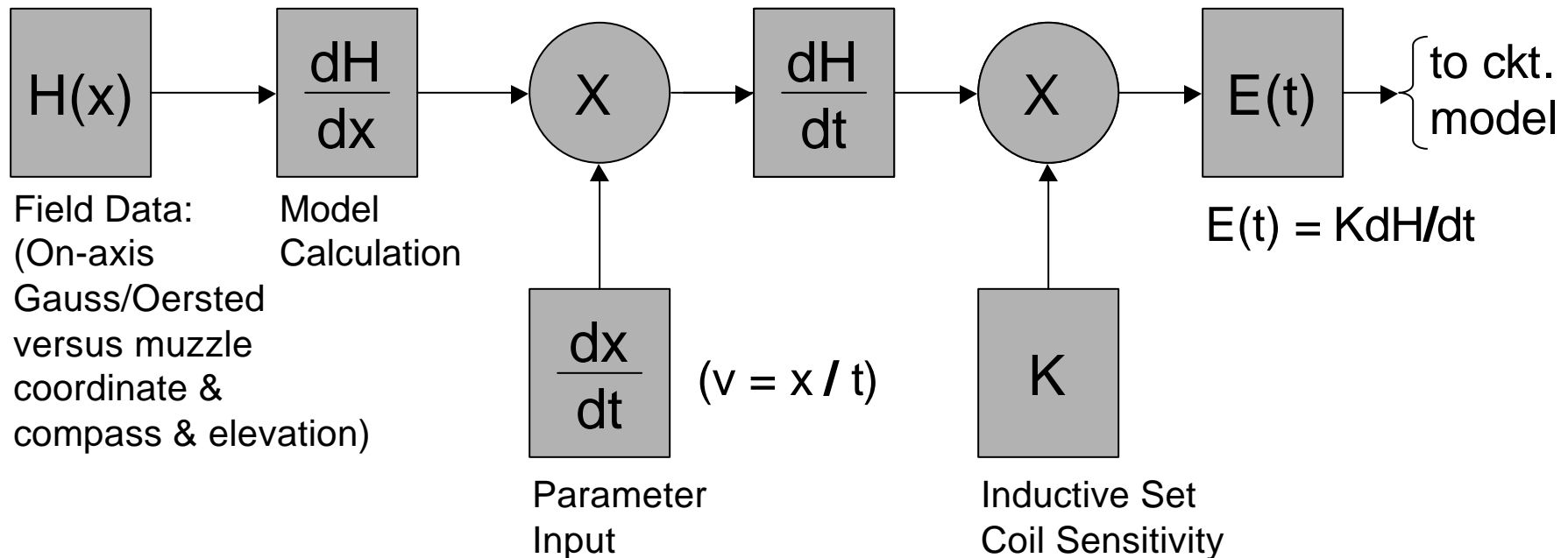


120mm Mortar Tube Static Signatures

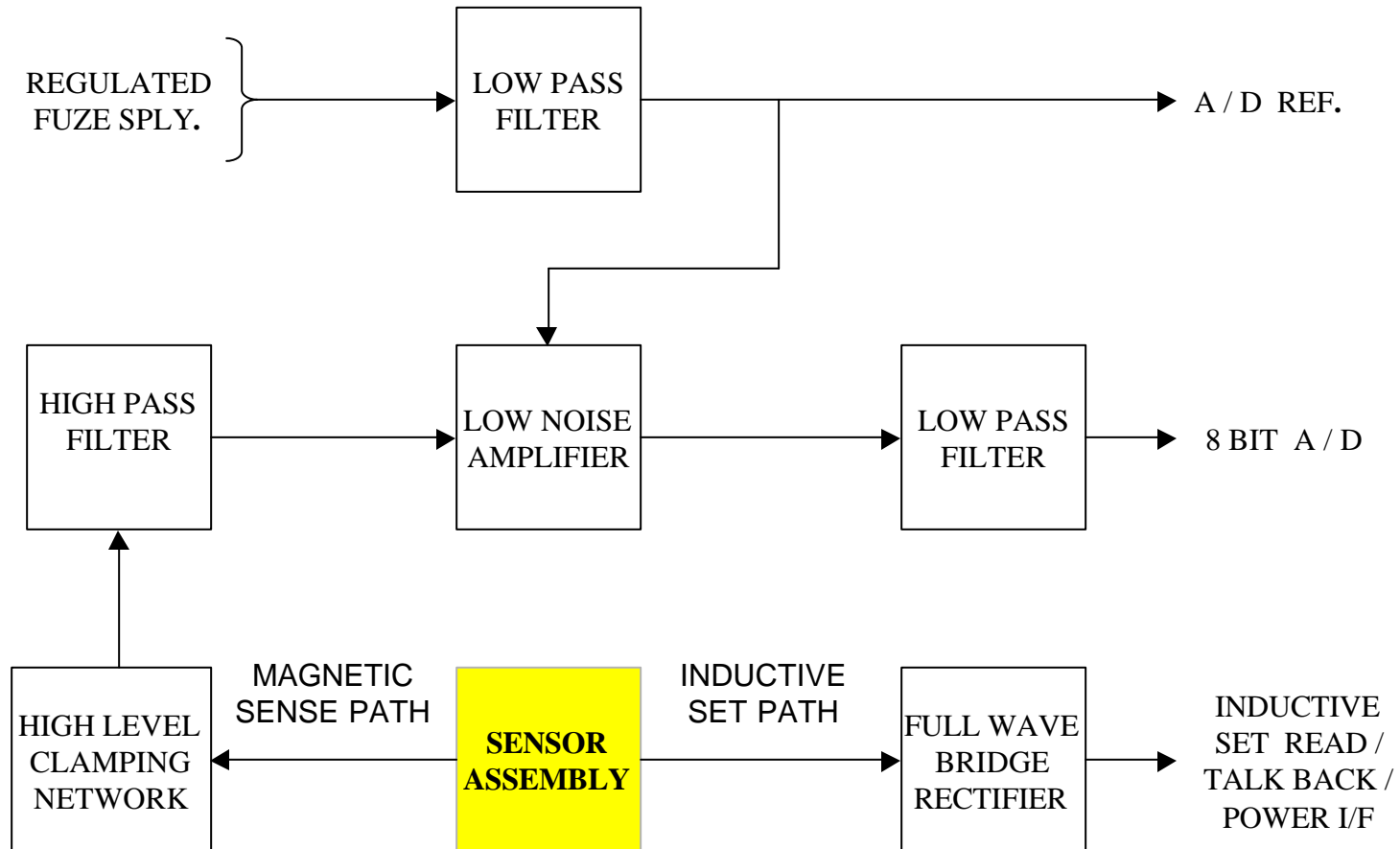


Sensor Static Data Analysis Modeling

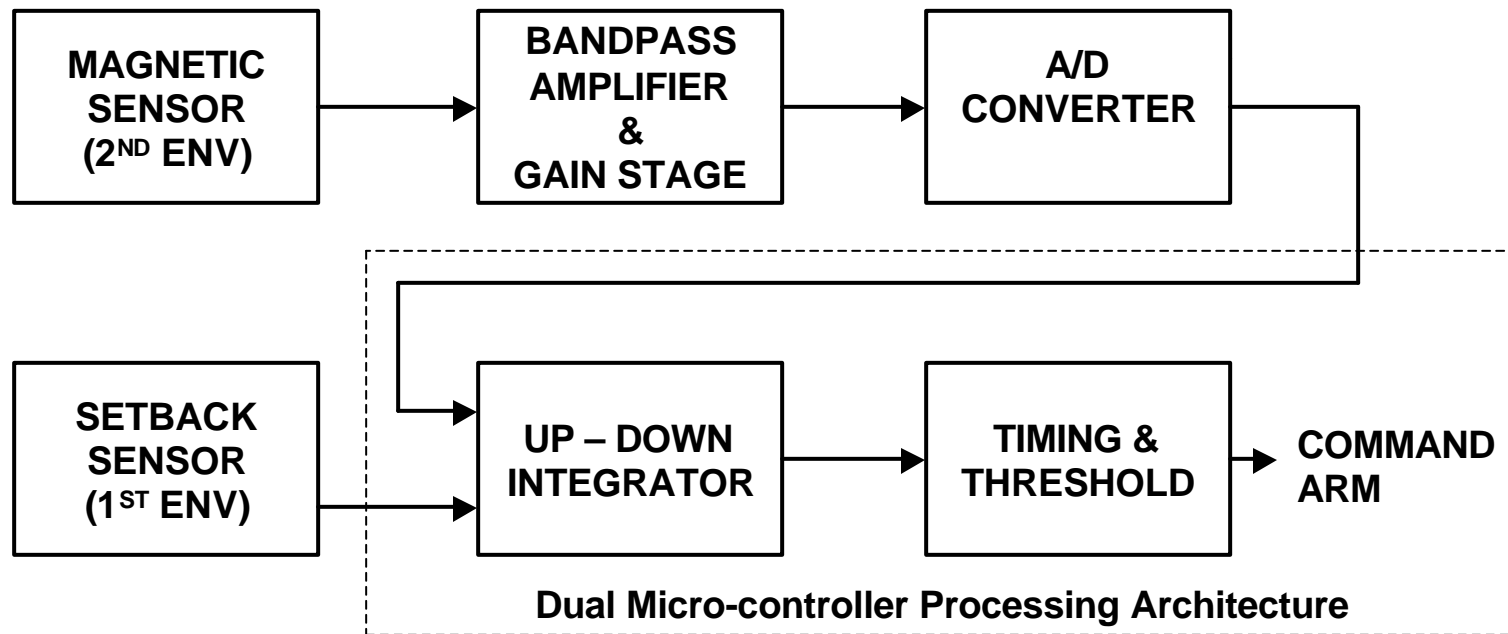
Static magnetic data is converted to velocity dependent voltage model for circuit simulation



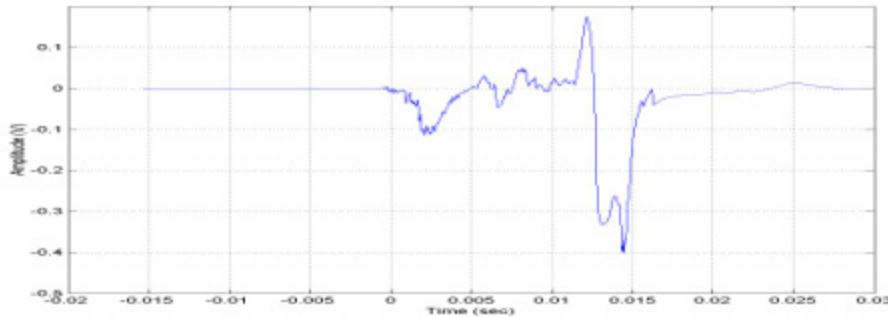
2ND Environment Sensor Architecture



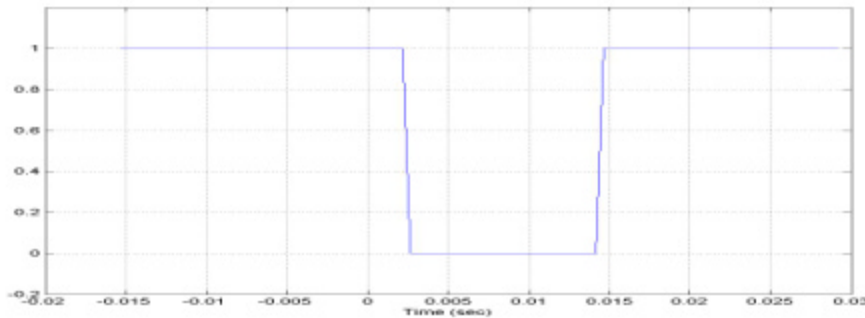
Sensor Signal Processing Path



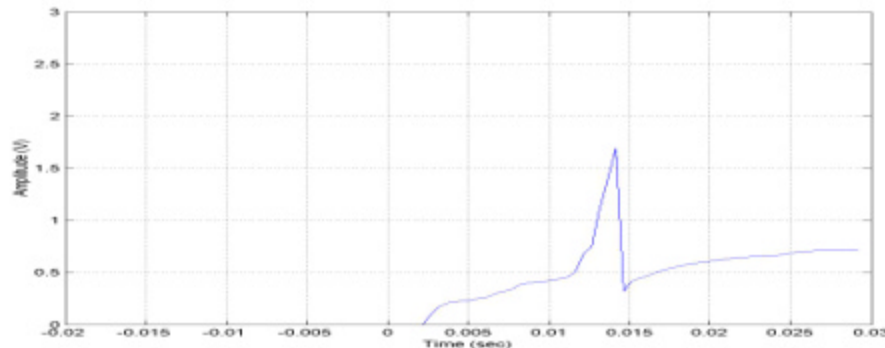
Sensor Waveform Processing Example (120mm Mortar Tube)



2nd Environment Magnetic Sensor
(Pre-Processed Waveform)



1st Environment Setback Sensor



2nd Environment Magnetic Sensor
(Post-Processed Waveform)
(Filtered and Integrated)



2nd Environment Sensor Summary



Completed:

- Static Tube Characterization Tests Performed (60, 81, 120mm)
- Limited Dynamic Environment Tube Measurements Conducted (20 tests on selected 60, 81, and 120mm mortar tubes at all charge conditions (ambient temp). Data collected included magnetic sensor, setback sensor, and round acceleration (selected sampling).
- Sensor data reduction and analysis conducted
- Sensor algorithm design

Planned for 2nd Quarter 2002:

- Algorithm implementation and dynamic Re-test planned
- Design Validation